Standardisation of components and work methods aid in achieving the high productivity, low inventory objectives of JIT systems.

Close relationships with suppliers enable JIT systems to operate with very low levels of inventory.

(vi) **Close Supplier Ties :** Because JIT systems operate with very low levels of inventory, close relationships with suppliers are necessary. Stock shipments must be frequent, have short lead times, arrive on schedule and be of high quality. A supplier may have to deliver goods to a factory as often as several times per day. Purchasing managers focus on reducing the number of suppliers, using local suppliers and improving supplier relations.

Manufacturers using JIT systems generally utilise local suppliers. Firms that have no suppliers close by must rely on a finely tuned supplier delivery system. Geographic proximity of suppliers enable the firms to reduce the need for safety stocks.

Firms implementing JIT systems reduce the number of their suppliers considerably. This approach puts a lot of pressure on these suppliers to deliver high quality components on time. JIT users extend their contracts with their suppliers and give them firm advance order information. In addition, they include their suppliers in the early phases of product design to avoid problems after production has begun. They also work with their suppliers' vendors to achieve JIT inventory flows throughout the entire supply chain.

Users of JIT system also find that a cooperative orientation with suppliers is essential. The JIT philosophy looks for ways to improve efficiency and reduce inventories throughout the supply chain. Close cooperation between firms and their suppliers can be a win-win situation for every one. Better communication of component requirements enables more efficient inventory planning and delivery scheduling by suppliers, thereby improving profit margins of suppliers. Customers can then negotiate lower component prices. Suppliers also should be included in the design of new products so that inefficient component designs can be avoided before production begins. Suppliers should be considered as partners in a venture wherein both parties have an interest in maintaining a long term profitable relationship.

Flexible workforce comprises workers having multiskills trained to perform more than one job or task.

(vii) **Flexible Workforce :** Workers in flexible work force can be trained to perform more than one job. When the skill levels required to perform most tasks are low, a high degree of flexibility in the workforce can be achieved with little training. In situations requiring higher skill levels, shifting workers to other jobs may require extensive, costly training. Flexibility can be very beneficial : workers can be shifted among workstations to help relieve bottle-necks as they arise without resolving to inventory buffers – an important aspect of the uniform flow of JIT systems. Multi-skilled workers may do the job of those who are on vacation or who are absent due to sickness.

(viii) **Line Flow Strategy :** A line flow strategy can reduce frequency of set-ups. If volumes of specific products are large enough (mass production), groups of machines and workers can be organised into a product lay-out to eliminate set-ups entirely. If volume is insufficient to keep a line of similar products busy, *group technology* can be used to design small production lines that manufacture, in volume, families of components with common attributes. Change over from a component in one product family to the next component in the same family are minimal.

(ix) **Automated Production :** Automation plays a big role in JIT systems and is a key to low cost production. Money freed up because of JIT inventory reductions can be invested in automation to reduce costs. The benefits, of course are greater profits, greater market share or both. However, automation should be planned carefully.

(x) **Preventive Maintenance :** Because JIT emphasises finely tuned flows of materials and little buffer inventory between workstations, unplanned machine down time can be

disruptive. Preventive maintenance can reduce the frequency and duration of machine down time. Maintenance is done on a schedule (frequency) that balances the cost of the preventive maintenance program against the risks and costs of machine failure.

Total preventive/productive maintenance concept makes workers responsible for routinely maintaining their own equipment and to develop employee pride in keeping their machines in top condition. This is however restricted for simple maintenance tasks such as lubrication, cleaning and minor adjustment of the machines. Maintenance of high-tech machines need trained specialists.

JIT Manufacturing Versus JIT Purchasing

Just-in-time manufacturing is an organisation-wide quest to produce output within the minimum possible lead time and at the lowest possible total cost by continuously identifying and eliminating all forms of *waste* and *variance*. ***Just-in-Time purchasing*** has the same pull type approach used in JIT manufacturing (or JIT production) applied to purchasing shipments of parts from suppliers. The essentials of JIT purchasing are :

JIT manufacturing: An organisation-wide approach to produce output with in the minimum possible lead time and at the lowest possible total cost by continuously identifying and eliminating all forms of waste and variance.

(i) ***Supplier development*** and ***supplier relation*** undergo fundamental changes. The supplier and customer have *co-operative relationship* which is also known as *subcontractor network* and suppliers are referred to as *co-producers*. Sensitive information, assistance in reducing costs and improving quality and even financing are often shared by customers and suppliers.

(ii) Purchasing departments develop *long term relationships* with few suppliers rather than a short term relationship with many suppliers.

(iii) Although price is important, delivery schedules, product quality and mutual trust and co-operation become the primary basis for the selection of suppliers.

JIT purchasing: Same pull type approach used in JIT manufacturing applied to purchasing shipments of parts and components from suppliers.

(iv) Suppliers are encouraged to extend JIT methods to their own suppliers.

(v) Suppliers are ordinarily located near the buying firm's factory or clustered together at some distance which will keep the lead times shorter and more reliable.

(vi) Shipments are delivered directly to the customer's production line usually through transportation vehicles owned by suppliers.

(vii) Parts are delivered in small, standard size containers with a minimum of paperwork and in exact quantities.

(viii) Delivered material is of near-perfect quality.

Pre-requisites for JIT Manufacturing

JIT production drastically reduces WIP inventories throughout the production system and thereby reduces the manufacturing lead times. The result is a smooth, uninterrupted flow of small lots of products throughout production. Most successful JIT applications have been in repetitive manufacturing operations where batches of standard products are produced at high speeds and high volumes with materials moving in a continuous flow.

Before implementing the JIT system, certain changes to the factory and the way it is managed must occur before the benefits of JIT can be realised. These changes are:

(i) Stabilise production schedules.

(ii) Make the factories focussed.

(iii) Increase production characteristics of manufacturing work centres.

(iv) Improve product quality.

(v) Cross-train workers so that they are multi-skilled and competent in several jobs.
(vi) Reduce equipment break downs through preventive maintenance.
(vii) Develop long-term supplier relationships that avoid interruptions in material flows.

Elements of a JIT Manufacturing System

The JIT manufacturing system has six major components or elements.

The important elements or components of a JIT manufacturing system are:

(i) Eliminating waste
(ii) Enforced problem solving
(iii) Continuous improvement
(iv) Involvement of people
(v) Total quality management and
(vi) Parallel processing.

The elements of JIT mentioned above are discussed in the following paragraphs.

(i) Eliminating waste : Eliminating waste of all kinds is the deep-seated technology behind JIT. *Waste* is any activity or action that adversely affects the value equation for the customer. Waste is a negative to be avoided or eliminated. Rather than increasing or enhancing value, waste reduces value. *For example,* if a company wants to compete on quality, flexibility and performance, then anything that reduces quality, decreases flexibility or adversely affects performance is a waste.

Managers must view waste, like value, from a customer's perspective. As an example, consider inventory, items that a firm keeps in stock, from raw materials to products currently in production (work-in-process) and completed products (finished goods) held in stock before selling. In general, operations managers view inventory as waste because of the following reasons :

(i) Inventory hides problem with the transformation process by allowing it to draw on stocks to avoid disruptions instead of correcting the cause of the problem.
(ii) Inventory consumes corporate resources such as storage space, money to pay for it, people to count and manage it.
(iii) Inventory increases lead times because more inventory means that more work is in the system at any time, which means that it takes longer for any item to go from start to finish. Reducing the waste of inventory should result in shorter lead times, higher quality through improvements in the process and lower costs and this should equate to higher value.

There are seven categories of waste in production that shoule be eliminated.

Categories of Waste : Shigeo Shingo, a JIT authority at Toyota, identified *seven wastes* in production that should be eliminated. They are listed in *Box 24.3*.

Japanese perspective of waste states: "waste is anything other than the minimum amount of equipment, materials, parts, space and worker's time which are absolutely necessary to add value to the product."

Box 24.4 gives examples of waste.

(i) **Waste of over production :** This waste occurs when the firm produces more goods than the market demands. "Make only what is needed now to eliminate the waste of over production" is a potential short cut towards this end.

(ii) **Waste of waiting time :** This waste occurs when flows of materials and information become stalled. Co-ordinate flows between operations and balance load imbalances by flexible workers and equipment to eliminate waste of waiting time.

(iii) **Waste of transportation :** This waste involves excessive handling or movement of goods as a result of such factors as poor lay-out, lack of coordination of processes, poor house keeping or inadequate methods of transportation. Design facility lay-out that reduces or eliminates materials handling and shipping to eliminate waste of transportation.

(iv) **Processing waste :** Excessive or unnecessary operations or actions also produce waste. Rework of correcting processing problems outside the normal process flow falls into this category. Eliminate all irrelevant production steps to eliminate processing waste.

(v) **Inventory waste :** This waste occurs when a process builds more than the firm needs to protect the system against problems such as excessively high scrap, shortages in vendors' deliveries and late arrival of materials. Eliminate this waste by reducing set up times, increasing production rates and better co-ordination of production rates between work centres.

(vi) **Waste of motion and effort :** Some waste results from unnecessary human activity. Efficiency requires reducing any unnecessary motion or efforts in the processing steps. Improve productivity and quality by eliminating unnecessary human motions, make necessary motions more efficient, mechanise, then automate to eliminate waste of motion and effort.

(vii) **Waste from product defects :** Creating defective products, consumer resources and correcting the defects consume some more resources. It also increases lead time by adding to processing steps. Eliminate defects and inspection. Make defects free product to eliminate waste due to defective products.

Box 24.4 : Examples of Waste

- Inspections of incoming materials
- Illogical paper trails for materials orders
- Excessive handling of work on the shop floor
- Confusion on the floor
- Sequential design process
- Some inventories
- Continuously working to correct acute problems in the processes (*i.e.* fire fighting) and
- Excess idle capacity

The logic revolving around producing in lots is because of set-up times. If the set-up and adjustment time is long (high cost), then more products should be produced in one batch in order to reduce set-up cost per unit. Operating like this has the effect of creating more inventories.

JIT systems concentrate on reducing the cost of setting up machines to avoid the negative aspects of producing small lot sizes. This principle is known as *single minute exchange of die (SMED)*. SMED involves the work in the 1980s of Shigeo Shingo, of Toyota Motor Co. Japan, who spent 19 years rigorously analysing the set-up procedures related to automobile manufacture. The ultimate objective was to change a machine tool in less than ten minutes (hence the expression *single minute* exchange of die).

To effect SMED procedures, the logic is to establish the distinction between :

- External set-up : Machine is running and
- Internal set-up : Machine is stopped.

To maximise efficiency, where possible, the set-up procedures should be performed while a machine is running (external set-up), that is the activity is being performed in parallel with actual production time. Only those set-up procedures that cannot be performed unless the machine is stopped (internal set-up) should be carried out at this time. *For example,* the transfer of machine tools, moulds or dies to the storage area should only be performed while a machine is running. The actual changing of a die or a mould can normally only be performed while the machine is stopped. In general, set-up times can be reduced by :

(i) locating required inventory and machine tools closer to the operating area and

(ii) standardising the set-up functions of machines.

(vi) **Parallel Processing :** Parallel processing or synchronous operations wherever possible is an important part of JIT operations which can be performed in parallel and if performed in series, it takes more manufacturing lead time. This concepts is similar to that of *simultaneous engineering* or concurrent engineering. By carrying out product design and process design simultaneously, the time to bring the new products to the market is reduced. The same approach is adopted in companies that want to engage in time-based competition through JIT. In many cases, lay-out redesign and product design may be selected to achieve *parallel processing.* The additional costs can usually be more than offset by significant reduction in manufacturing lead times.

Parallel processing reduces manufacturing lead times.

Benefits of JIT System

Some of the benefits claimed for JIT systems are :

(i) Inventory levels are drastically reduced. Inventory turnovers as high as 50 to 100 times per year have been achieved. The raw materials inventory, work-in-process inventory and finished goods inventories have been reduced considerably.

(ii) The time taken for products to get through the factory (product throughput time or production cycle time) is greatly reduced, thus enabling manufacturers to engage in time-based competitions, using speed as a weapon to capture market share.

(iii) Product quality is improved and hence the cost of scrap is reduced. Product quality improves because of worker involvement in solving the causes of production problems.

(iv) Because the focus in manufacturing is on finding and correcting the causes of production problems, manufacturing operations are streamlined and problem free.

(v) With less-in-process inventory, less space is taken up by inventory and materials handling equipment.

(vi) Multi-skilled, flexible workforce brought benefits like less worker idle time, reduced overheads, fewer lay-offs due to demand fluctuations in specific product lines and increased responsiveness.

Major benefits of JIT system are:
- **Low inventory levels**
- **Shorter production cycle time**
- **Improved product quality**
- **Reduced WIP inventory**
- **Better labour utilisation.**

Some additional benefits of JIT systems are:

- Elimination of unpleasant suppliers such as those with late deliveries and unacceptable quality.
- Reduction in customer-related problems.
- Significant improvements in quality (near to zero defects).
- Improvements in communication.
- Reduction in floor space needs due to lesser work-in-process inventory and smaller lot sizes.
- Shorter lead times of suppliers, allowing them to respond more quickly to changing customer needs.
- Improvements in employee morale due to higher employee involvement and employee empowerment.
- Reduced pressure on inwards goods receiving and incoming inspection areas.

Major Tools and Techniques of JIT Manufacturing

Just-in-time manufacturing works at two different levels. As a large scale, organisation wide philosophy, it directs everyone's efforts at identifying and eliminating waste in the firm. This broad-based, strategic orientation is referred to as JIT or CORPORATE JIT or Big JIT. On the other hand, practitioners can focus on various analytical tools and techniques that are frequently associated with just-in-time manufacturing.

Shop-floor JIT or little JIT has nine tactical tools.

Often this tactical orientation is referred to as jit or shop-floor JIT or Little JIT. The tactical tools of little JIT are :

(i) Kanban system or Pull scheduling

(ii) Set up reduction (SMED)

(iii) Lean production

(iv) Poka-Yoke (Fool proofing)

(v) Quality at the source

(vi) Standardisation and simplification

(vii) Supplier partnerships

(viii) Reduced transaction processing and

(ix) Kaizen (continuous improvement).

These techniques are discussed in the following sections.

Kanban system: A physical control system consisting of cards and containers. The system is used to signal the need for more parts and to ensure that those parts are produced in time to support subsequent fabrication or assembly.

1. Kanban System or Pull Scheduling

To build only what customers demand when they demand, JIT manufacturing needs a scheduling system that can immediately and clearly communicate the demands of the customer to the delivery system. The Kanban or pull scheduling system does this. *'Kanban'* is a Japanese word meaning *"card"* and these cards are the means of communicating within, to and from a work centre. Kanbans are the heart of the JIT system. They effectively replace all written work orders, move tickets and routing sheets. No parts can be moved, produced or used without an appropriate Kanban. Parts and components are transferred from one work area to another in rigid plastic containers. These containers are just large enough to hold a small and fixed quantity of units of the same component reference. Different parts are not put into the same container. There are two kinds of Kanbans – production Kanban and withdrawal Kanban (or conveyance Kanban). The information written on Kanban includes reference number, storage areas and associated work centres.

Kanban: A Japanese word meaning "card" and these cards are the means of communicating within, to and from a work centre.

The purpose of the Kanban system is to signal the need for more parts and to ensure that those parts are produced in time to support subsequent fabrication or assembly. This is done by pulling parts through from the final assembly line. Only the final assembly line receives a schedule from the dispatching office and this schedule is nearly the same from day to day. All other machine operators and suppliers receive production orders (Kanban cards) from the subsequent (using) work centres. If production should stop for a time in the using work centres, the supplying work centres will also soon stop, since they will no longer receive Kanban orders for more materials.

The Kanban system is a physical control system consisting of cards and containers. To control movement of the containers, the Kanban cards (production cards and withdrawal or move cards) are used. These cards are used to authorise production and to identify parts in any container. The Kanban cards may be made of paper, metal or plastic and they generally contain the information shown in *Exhibit 24.2.*

Kanban cards take the place of shop paperwork used in traditional repetitive manufacturing.

Working of the Kanban System : *Exhibit 24.3* illustrates the working of the Kanban system.

Assume that eight containers are used between work centre A and B (A supplies B) and each container holds exactly 20 parts. The maximum inventory that can exist between these two work centres is then 160 units (*i.e.,* 8 × 20) since production work at work centre A will stop when all containers are filled.

Exhibit 24.2 : Kanban Cards

<table>
<tr><td colspan="3">Part No. W262
Part Name : Wheel</td><td rowspan="3">Preceding process: stamping A12
Subsequent process :
Rubber tyre B6.</td></tr>
<tr><td>Box Capacity</td><td>Box Type</td><td>Issue No.</td></tr>
<tr><td>20</td><td>B</td><td>4 of 8</td></tr>
</table>

Withdrawal Kanban

<table>
<tr><td>Part Number : X16032
Part Name : Wheel Rim
Stock location at which to store 1879-2
Container capacity : 20</td><td>Process stamping A12</td></tr>
</table>

Production Kanban

In the normal course, the eight containers might be distributed as shown in *Exhibit 24.3.* Three containers are located at work centre A in the output area filled with parts. One container is being filled at work centre A by the machine. One full container is being moved from work centre A to B, two containers are kept in the input area of work centre B and one container is being used at B. These 8 containers are needed since work centre A also produces parts for other work centres, machines at A may break down and time taken to move materials from work centre A to B is not exactly predictable.

Here is how the Kanban system works, assuming containers are moved one at a time. When a container of parts is emptied at work centre B, the empty container and associated withdrawal card are taken back to work centre A. The production card from a full container is removed from its container and replaced by the withdrawal card. The production card is then placed in the Kanban receiving post at work centre A, thereby authorising production of another container of parts (20 numbers in this case). The empty container is left at workstation A.

Exhibit 24.3 : Kanban System